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The Influence of Spatial Location on Same-Different Judgments of Facial Identity and Expression

Maurryce D. Starks
The Ohio State University

Anna Shafer-Skelton
The Ohio State University and University of California, San Diego

Michela Paradiso, Aleix M. Martinez, and Julie D. Golomb
The Ohio State University

The "spatial congruency bias" is a behavioral phenomenon where 2 objects presented sequentially are more likely to be judged as being the same object if they are presented in the same location (Golomb, Kupitz, & Thiemann, 2014), suggesting that irrelevant spatial location information may be bound to object representations. Here, we examine whether the spatial congruency bias extends to higher-level object judgments of facial identity and expression. On each trial, 2 real-world faces were sequentially presented in variable screen locations, and subjects were asked to make same-different judgments on the facial expression (Experiments 1–2) or facial identity (Experiment 3) of the stimuli. We observed a robust spatial congruency bias for judgments of facial identity, yet a more fragile one for judgments of facial expression. Subjects were more likely to judge 2 faces as displaying the same expression if they were presented in the same location (compared to in different locations), but only when the faces shared the same identity. On the other hand, a spatial congruency bias was found when subjects made judgments on facial identity, even across faces displaying different facial expressions. These findings suggest a possible difference between the binding of facial identity and facial expression to spatial location.

Public Significance Statement
This study provides evidence that spatial location can influence perceptual judgments of facial identity and facial expression. The results also highlight a potential asymmetric relationship between facial identity and facial expression processing.

Keywords: object-location binding, spatial location, facial expression

Objects contain many different features and parts that must be bound together to successfully navigate one's environment. For example, recognizing a face entails integrating low-level features (e.g., color, shape, texture, and motion) and high-level features (e.g., configural information, expressions). The binding problem (Treisman, 1998) examines how the brain successfully combines information about an object, its characteristics, and its location in space to make-up a single representation in a person's mind. The outcome of this process allows objects in one's environment to be correctly identified. Object recognition is often thought of as a hierarchical process in the brain, beginning with processing of low-level features, combining them to create a representation of the object, and lastly identifying what the object is. During this process, information about the object's location is also encoded and used for identification. Identifying and locating an object are often thought of as separate cognitive or neural processes (Goodale

Maurryce D. Starks, Department of Psychology, The Ohio State University; Anna Shafer-Skelton, Department of Psychology, The Ohio State University, and Department of Psychology, University of California, San Diego; Michela Paradiso, Department of Neuroscience, The Ohio State University; Aleix M. Martinez, Department of Electrical and Computer Engineering, The Ohio State University; Julie D. Golomb, Department of Psychology and Department of Neuroscience, The Ohio State University.

Julie D. Golomb, Michela Paradiso, and Anna Shafer-Skelton were involved in the conceptualization of the study. Michela Paradiso, Anna Shafer-Skelton, Julie D. Golomb, and Aleix M. Martinez designed the experiments. Michela Paradiso, Anna Shafer-Skelton, and Maurryce D. Starks collected and analyzed the data. Maurryce D. Starks drafted the manuscript, and all authors contributed feedback on the manuscript. We thank members of the Golomb lab for their insight and help with data collection. This study was supported by grants from the National Institutes of Health (R01-EY025648 to Julie D. Golomb, R01-EY020834 to Aleix M. Martinez and Julie D. Golomb), the Alfred P. Sloan Foundation (Julie D. Golomb), and the Human Frontier Science Program (RGP0036/2016 to Aleix M. Martinez). Data and materials will be publicly available on the Open Science Framework (https://osf.io/mfc3u/).

Correspondence concerning this article should be addressed to Julie D. Golomb, Department of Psychology, The Ohio State University, 225 Psychology Building, 1835 Neil Avenue, Columbus, OH 43210. E-mail: golomb.9@osu.edu

& Milner, 1992; Mishkin & Ungerleider, 1982), yet they interact in interesting ways. Some have proposed that before an object can be identified, the object's location must be processed in order for an observer to focus their attention, with spatial attention then serving as the "glue" that binds features into an integrated object (Treisman & Gelade, 1980). Other studies have suggested that initial object representations incorporate spatial location while simultaneously integrating object features (Treisman & Zhang, 2006) and that higher-level processes (e.g., object-recognition) might depend on the combination of object feature and spatial location information (Gronau, Neta, & Bar, 2008). Spatial location information may also play a role in how an object's features are processed in other ways; for example, by protecting the integrity of object features from interference from other objects (Harris, Harris, & Corballis, 2020), while also being useful for distinguishing two items in working memory (Pertzov & Husain, 2014). Moreover, certain features, for example, color and orientation, may be bound to the location of their objects and linked together by their shared location (Kovacs & Harris, 2019; Schneegans & Bays, 2017).

Even more strikingly, encoding of irrelevant location information can even influence perceptual judgments of an object's features and identity. The "spatial congruency bias," first reported by Golomb et al. (2014), reveals the tendency for observers to judge two sequential items presented in the same location as being the same identity, even when the items are not identical. The spatial congruency bias has been observed with simple stimuli (e.g., oriented gabors, letter strings) and stimuli as complex as computer-generated faces (Cave & Chen, 2017; Golomb et al., 2014; Shafer-Skelton, Kupitz, & Golomb, 2017). The spatial congruency bias effect is measured as a difference in response bias when stimuli are presented in the same versus different locations, such that two objects presented in the same location are more likely to be perceived as having the same orientation, color, shape, and even facial identity, compared to if the objects appeared in different spatial locations.

Prior literature has proposed that the spatial congruency bias is a perceptually based effect (Golomb et al., 2014; Shafer-Skelton et al., 2017) thought to reflect a low-level, automatic encoding of spatial information perhaps tied to early visual processes (Bapat, Shafer-Skelton, Kupitz, & Golomb, 2017; Finlayson, Zhang, & Golomb, 2017; Finlayson & Golomb, 2016; Shafer-Skelton et al., 2017). This makes it all the more striking that the congruency bias influences perception of stimuli as complex as faces, which are thought to be processed in higher-level visual areas later in the visual hierarchy (Kanwisher, McDermott, & Chun, 1997; Kovács, Cziraki, Vidnyánszky, Schweinberger, & Greenlee, 2008; Srinivasan, Golomb, & Martinez, 2016). The fact that spatial location would alter judgments of facial identity is significant in light of how important facial recognition is from an ecological perspective. Throughout the course of a lifetime, the average human will come across a massive amount of faces and will be able to recall thousands of these identities (Jenkins, Dowsett, & Burton, 2018).

Although humans discriminate between human faces better than any other type of object (Werner, Kühnel, & Markowitsch, 2013), there are a number of other examples where facial-identity judgments are not immune to low-level influences. For example, there appears to be a relationship between facial processing and the location of a stimulus in an observer's visual field, such that there is an advantage in facial processing in the upper visual fields compared to lower visual fields (Carlei, Framorando, Burra, & Kerzel, 2017; Felisberti & Currie, 2019; Felisberti & McDermott, 2013; Hagenbeck & Van Strien, 2002), and for faces processed centrally compared to in the periphery (Levy, Hasson, Avidan, Hendler, & Malach, 2001). The perceived gender of a face can even be biased by its visual field location (Afraz, Pashkam, & Cavanagh, 2010). Spatiotemporal factors can also influence facial identity judgments when multiple faces are shown in sequence. Perception of the identity of a novel face is biased by the identity of the preceding faces (Hsu & Lee, 2016; Liberman, Fischer, & Whitney, 2014), a phenomenon known as the serial dependence effect (Fischer & Whitney, 2014). The serial dependence effect may be related to the spatial congruency bias described above, especially since serial dependence is stronger for objects appearing in the same or nearby spatial location (Fischer & Whitney, 2014).

The findings that facial identity judgments can be influenced by spatial location lead to another question: How pervasive is location's influence on judgments for other higher-level processes, like those for facial expression recognition? Humans use facial expressions to convey feelings about emotional state and intentions (Horstmann, 2003; Seidel, Habel, Kirschner, Gur, & Derntl, 2010), and even noisy interpretations of these expressions may lead to success or lack thereof in one's social environment (Barrett, Adolphs, Marsella, Martinez, & Pollak, 2019). Recognition of facial expressions is thought to rely on the perception of different facial action units (Ekman & Friesen, 1978; Martinez, 2017), which may be processed in the superior temporal sulcus (pSTS; Srinivasan et al., 2016). Neuroimaging studies have suggested that facial image processing is localized in various face-selective regions like the fusiform face area (FFA), occipital face area (OFA), and the superior temporal sulcus (pSTS; Kanwisher & Barton, 2011). Face processing within these regions may follow a hierarchical structure with the most posterior OFA region processing facial parts (Pitcher, Walsh, Yovel, & Duchaine, 2007), and this information being fed into two higher-level face processing regions (Haxby, Hoffman, & Gobbini, 2000, 2002): the FFA being more involved in facial identity, and the pSTS processing more dynamic and social features of faces, including facial expressions (Martinez, 2017; Pitcher, Dilks, Saxe, Triantafyllou, & Kanwisher, 2011; Srinivasan et al., 2016). Many additional factors can influence facial expression processing in humans, for example, attention, context, and memory, and consequently various other nonvisual brain regions have also been implicated in processing facial expressions, such as the limbic system (Barrett et al., 2019; Derryberry & Tucker, 1992; Gur et al., 2002) and the prefrontal cortex (Hooker, Gyurak, Verosky, Miyakawa, & Ayduk, 2010; Wolf, Philippi, Motzkin, Baskaya, & Koenigs, 2014), which are even further downstream from early visual areas.

The goal of the current study is to ask whether judgments of facial identity and expression differ in terms of the object-location binding captured by the spatial congruency bias effect. One possibility is that we might observe a robust spatial congruency bias for judgments of both identity and expression, which would indicate that even judgments as complex and ecologically relevant as facial expression perception are still subject to influence by low-level spatial information. The fact that the serial dependence phenomenon has been recently extended to facial expression tasks (Liberman, Manassi, & Whitney, 2018) could support this possibility. On the other hand, one of the proposed theoretical accounts for the existence of the spatial congruency bias is that it reflects some default or learned assumptions about the world that objects in the same location tend to be the same object (Golomb et al., 2014). In the real world, it is highly unlikely for a face in a given location to change its identity, whereas a face can change expression rapidly and frequently. Because of its relative invariance, facial identity can be considered a static property, that is, unlikely to change across time; whereas facial expression could be considered a dynamic property, that is, likely to change countless times over time (Lander & Butcher, 2015). Consequently, if the spatial congruency bias on some level reflects these implicitly learned expectations, then one might predict that it be present when making judgments on facial identity but not for judgments of facial expressions of emotion.

In the current study, we ask whether the spatial congruency bias effect extends to judgments of facial expression. We also further probe the previously reported spatial congruency bias for facial identity (Shafer-Skelton et al., 2017), asking whether it can be extended from computer-generated faces to more naturalistic photographs of real faces, and more importantly, whether the spatial congruency bias found for facial identity (and potentially expression) still persists when low-level image features cannot be relied upon to complete the task. In Shafer-Skelton et al. (2017), when two faces were the same facial identity, they were identical images in every way, including low-level information (i.e., pixel color/luminance). Researchers have examined the strategies observers use to make judgments between two faces, including, for example, facial-feature based and nonfacial cues (Mueller & Wherry, 1980; Yankouskaya, Humphreys, & Rotshtein, 2014), and it is possible that observers may use a low-level image-matching strategy when making judgments between two facial identities if that information is available. Our work specifically aims to test whether a spatial congruency bias is present in cases where a strict image-matching strategy is not possible. Although a spatial congruency bias for face perception would be interesting in either case, the theoretical consequences would be greater if it applies to truly higher-level judgments of facial identity and expression.

To test these questions, we used a richer stimulus set consisting of faces that varied in both identity and expression, such that two sequentially presented faces could be the same or different identity, the same or different expression, and presented in the same or different location. Location was always irrelevant to the task, which was a judgment of either facial identity or facial expression. In Experiment 1, we asked if there was a spatial congruency bias for facial expression judgments, when the task-irrelevant facial identity dimension was held the same; that is, are participants more likely to judge a person's face as exhibiting the same expression across two presentations in which the face appears at the same location versus different locations? This is the opposite but analogous design to the facial identity experiment in Shafer-Skelton et al. (2017), which found a spatial congruency bias for facial identity judgments, across stimuli that always shared the same neutral expression. In Experiment 2, we tested the spatial congruency bias while participants performed the facial expression task across images with *different* facial identities; that is, are two people's faces more likely to be perceived as exhibiting the same expression when they appear at the same location versus different locations? Finally, in Experiment 3, we returned to the question of facial identity judgments and asked if the previously reported spatial congruency bias holds when the two stimuli display different facial expressions.

General Method

Subjects

All three experiments included 16 subjects (with a different set of subjects in each experiment), all of whom gave informed consent to participate in the studies. Subjects indicated that they had normal or corrected-to-normal vision prior to starting the experiment. Subjects received course credit or monetary compensation for their time. These studies and their protocols were approved by the Ohio State University Behavioral and Social Sciences Institutional Review Board. Sample size was chosen in advance to match the sample size used in prior spatial congruency bias studies, particularly the facial identity experiment reported in Shafer-Skelton et al., (2017, Experiment 2), to facilitate comparison across studies. That sample size was initially chosen based on a power analysis of the original spatial congruency bias effect (Expt 1 of Golomb et al., 2014), which had an effect size of dz = 1.01 for the comparison of SameLocation versus Different-Location bias, and statistical power (1-β) of 0.96 to detect the effect with $N = 16$. (Note that the more recent Shafer-Skelton et al. [2017] Experiment 2 reported an effect size of dz = 1.30 for this contrast, suggesting that a sample size as small as $N = 7$ would be sufficient to detect this effect with 0.8 power, but we opted to maintain the $N = 16$ sample size for consistency.)

Experimental Setup

Stimuli were presented using Psychophysics Toolbox extension (Brainard, 1997) for MATLAB (MathWorks, Natick, MA), on a 21-in (53.34-cm) flat screen CRT monitor with a refresh rate of 85 Hz. Subjects were seated at a chinrest 61 cm from the monitor.

Eye-Tracking

Eye position was monitored with an EyeLink 1000 eye-tracking system recording pupil and corneal reflection position. Fixation was monitored for all experiments, and if at any point the subject's fixation deviated more than 2°, the trial was aborted and repeated later in the block. An average of 5.5% (Experiment 1), 7.5% (Experiment 2), and 6.0% (Experiment 3) of trials were aborted and rerun during each respective experiment.

Stimuli

Face stimuli were selected from a database of real faces displaying different facial expressions of emotion (Du, Tao, & Martinez, 2014). Specifically, stimuli were headshot photographs of adult men and women from various racial groups in front of a white background. From this database we selected 10 different real-world faces (10 facial identities: four males, six females) each displaying five different facial expressions of emotion (happy, happily surprised, happily disgusted, surprised, and neutral). This set of faces underwent additional morphing or image processing as described in the individual experiments. Visual masks occupying the same location and size as the face stimuli were generated by randomly setting pixels to a value between black and white.

Procedure

All three experiments had identical procedures, except in the judgment participants were asked to make about the stimuli. Figure 1

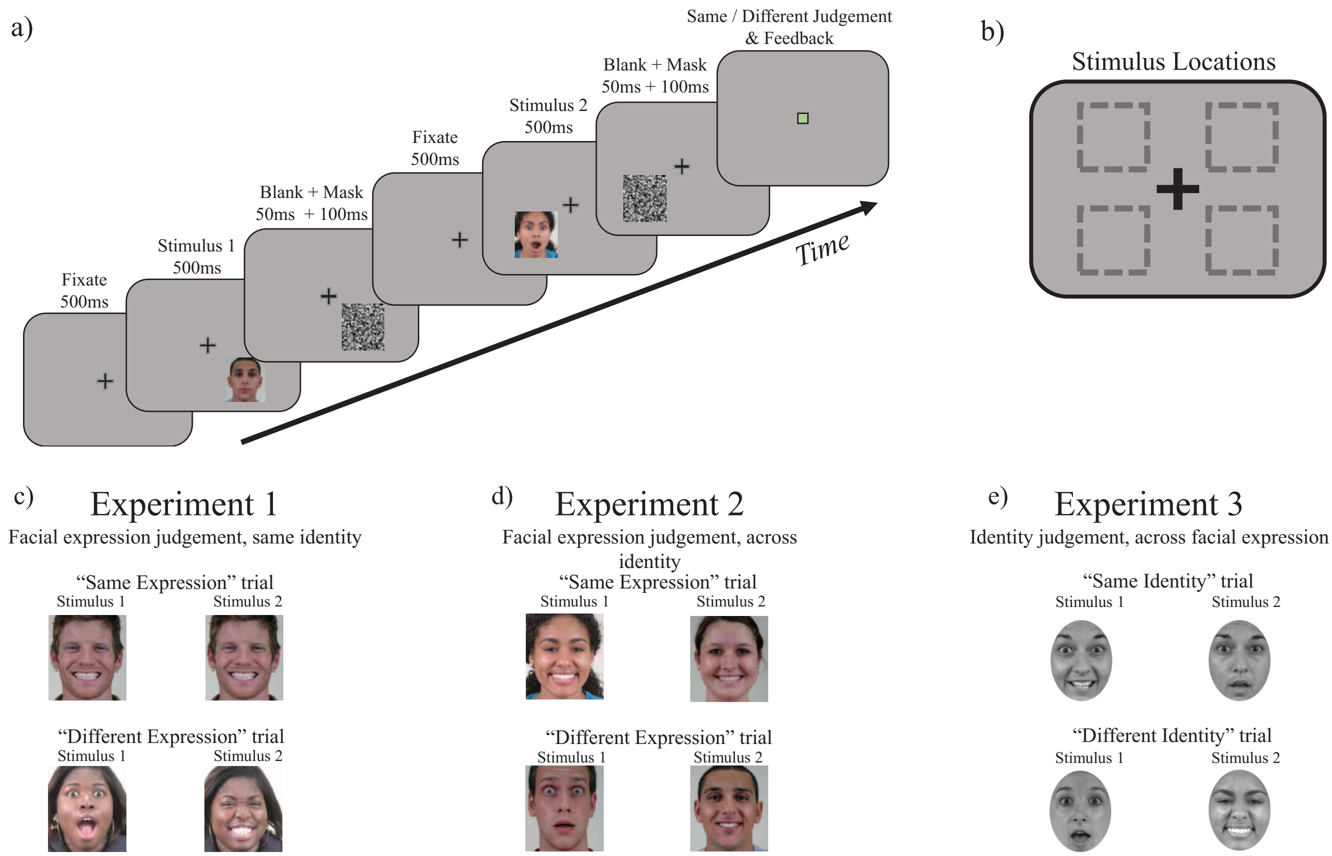

Figure 1. Experimental design and conditions. a: Trial timing for Experiment 1–3 (shown is an example trial from Experiment 2, expression judgment across identity). While fixating on a central cross, participants were presented with two face stimuli followed by masks. The task was to judge if the face stimuli displayed the same facial expression of emotion (Experiments 1 and 2) or facial identity (Experiment 3). Subjects received feedback on their performance after each trial. b: Schematic of stimulus presentation locations, c: Example of same expression trial and different expression trial stimuli for Experiment 1. d: Example of same expression trial and different expression trial stimuli for Experiment 2. e: Example of Same identity trial and different identity trial stimuli for Experiment 3. See the online article for the color version of this figure.

illustrates the progression of the stimuli as it was presented to the participants. At the start of the trial, participants were instructed to fixate on a fixation cross or dot in the middle of the screen for 500 ms. Next, a face stimulus would appear in the periphery (upper left, upper right, lower left, or lower right) and remained visible for 500 ms. Stimuli were sized at $7 \times 7°$, centered at 7.09° eccentricity and were displayed on a gray background. Without moving their eyes from the cross, the participants were instructed to take note of the stimulus' facial expression (Experiments 1 and 2) or identity (Experiment 3). The stimulus was followed by a blank screen (50 ms) and masked (100 ms). Next, participants would maintain fixation on the cross for another 500-ms delay. Subsequently, a second face stimulus was displayed in either the same exact location as the first stimulus or a different peripheral location for 500-ms. Because many studies report variations in facial processing efficiency between upper and lower visual fields (Carlei et al., 2017; Felisberti & McDermott, 2013; Hagenbeck & Van Strien, 2002), to improve consistency both stimuli were always presented in either the same or horizontally adjacent location. The second stimulus was again followed by a blank screen (50 ms) and masked (100 ms).

Participants would then indicate if they believed the two faces displayed the same expression (Experiments 1 and 2) or identity (Experiment 3). Participants completed this task by completing a same/different judgment; location was irrelevant to the prompt. Participants were given feedback on their performance. If participants' same/different responses were correct, a green square would appear on the screen, while a red square appeared for incorrect responses. If participants broke fixation with the cross, a large red "x" would appear on the screen indicating that the trial was cut and would have to be repeated later in the block.

Each experiment contained 10 experimental blocks with 16 trials in each block. Before the start of the experimental blocks, participants first completed a practice block to get acclimated to the task. Next, participants completed a staircasing block, and the final staircasing value was set as the morph value for the subsequent first experimental block.

Analysis

Our primary effect of interest across all experiments was the spatial congruency bias, which is calculated as the difference in response bias for same location versus different location conditions (Golomb et al., 2014; Shafer-Skelton et al., 2017). We used signal detection theory to calculate response bias using the criterion (c) measure, applying the standard formula (Stanislaw & Todorov, 1999): Response bias = -[z(hit rate) + z(false alarm rate)]/2. (Note that although it is often assumed that response bias measures reflect decision-level effects, response bias can also reflect perceptual-level processes, as in the case for the spatial congruency bias; Shafer-Skelton et al., 2017; Witt, Taylor, Sugovic, & Wixted, 2015). We defined a "hit" as a participant's correct indication of same identity (or same facial expression), and a "false alarm" as when a participant indicated two stimuli were the same identity (or facial expression) when they were actually different. Response bias was calculated separately for each subject, for the same location and different location conditions. To evaluate the spatial congruency bias, we then compared the response bias for the different location condition to the response bias for the same location condition. A negative shift in response bias indicates an increased likelihood to respond "same facial expression" (or "same identity") in the same location condition. Although our principal measure was the spatial congruency bias (difference in response bias), we report other measures of performance (e.g., reaction time [RT] and sensitivity [d']) for the sake of transparency.

Values for all measures were averaged separately for each subject and condition. Values for same and different location conditions were compared within each experiment via two-tailed paired t tests; effect sizes were calculated with Cohen's d. Effects across experiments were compared via between-subjects mixed effects analyses of variance (ANOVAs). Trials on which subjects failed to respond, or whose response times were greater than 2.5 standard deviation of the subject's mean were excluded.

Experiment 1: Facial Expression Task, Same Identity

Overview

In Shafer-Skelton et al. (2017), participants were significantly more likely to judge two faces as being the same identity when they were presented in the same spatial location. Here we ask if this spatial congruency bias extends to judgments of facial expressions of emotion. In Shafer-Skelton et al. (2017), all face images were of people displaying neutral facial expressions. Thus, the facial expression was always the same across the two stimuli within a trial, and the stimuli only varied in facial identity (task-relevant dimension) and/or stimulus location (task-irrelevant dimension). In Experiment 1 we sought to test the question of whether there is an analogous spatial congruency bias for expression judgments. Within each trial, the two face stimuli were always the same facial identity (i.e., the same person), but they could differ in facial expression (task-relevant dimension) and/or stimulus location (task-irrelevant dimension). Although location was irrelevant to the task, we wanted to determine if stimulus location biased the same/different judgment.

Method

Subjects. Sixteen subjects (nine females, seven males; M age = 18.43 years; range = 17–20) participated in this experiment.

Stimuli. Stimuli were color photographs of men and women displaying various facial expressions in front of a white background, from the database of Du et al. (2014). We selected a stimulus set of eight facial identities (four males, four females; from the larger set of 10 faces described above), each displaying the following facial expressions: happy, happily disgusted, happily surprised, surprised, and neutral emotion. In a previous study, these facial expression categories were shown to have more between-subjects agreement and were the fastest to identify visually compared to other categories (Du & Martinez, 2013). We then created a sequence of morphed images for each identity by blending a "target expression" (e.g., happy) into the "neutral" image of the same model, with varying degrees, using FantaMorph software (Abrosoft; http://www.abrosoft.com). Consequent morph sequences contained 50 images for each identity in the following 4 categories: happy-to-neutral, happily disgusted-to-neutral, happily surprised-to-neutral, and surprised-to-neutral. Within each morph sequence, Image 1 was the image most clearly exhibiting that expression (e.g., 100% happy), Image 25 was a weaker version of that expression (e.g., 50% blend of happy and neutral faces), and Image 50 was the 100% neutral image. These morphs were used to calibrate the difficulty of the same-different facial expression judgment on an individual participant basis. Staircasing was conducted during a practice task to determine the morph percentage that achieved roughly 75% accuracy in the same-different facial expression task. The final staircase value was chosen as the morph percentage for all trials of the first block. For example, a given participant might have required a morph level of 85% (emotion-to-neutral ratio), whereas another participant might only have required the 60% morphs to achieve the desired accuracy range. Morph values were updated as necessary after each block if performance was greater than 85% or less than 60%.

During the experiment, each trial always presented two faces of the same identity (Figure 1c). The first face stimulus was randomly chosen from the 8 identities and 4 expression categories on each trial (at the stair cased morph level). On same expression trials, the second face stimulus was the identical image as the first. On different expression trials, the second face stimulus was chosen from a different facial expression category, of the same identity and morph value. For example, if Stimulus 1 was Face A chosen from the happy-to-neutral category and had a morph value of 10 (80% happy), Stimulus 2 could have been Face A from the surprised-to-neutral category with a morph value of 10 (80% surprised). The location of the first face stimulus was randomly assigned on each trial to one of four positions. On same location trials, Stimulus 2 was presented in the same exact location as stimulus 1. On different location trials, Stimulus 2 was always presented in the horizontally adjacent position; for example, if Stimulus 1 was presented in the lower left position, Stimulus 2 would be presented in the lower right position.

Results

Our primary effect of interest is the spatial congruency bias, calculated as the difference in response bias for same versus different location conditions. Figure 2 shows the response bias, along with the proportion of "same expression" responses illustrating hit and false alarm rates, for same and different location conditions. Table 1 reports means (and standard deviations) for RT, d-prime, proportion "same" responses, response bias, and accuracy.

Spatial congruency bias. Paired t tests revealed a significant difference in response bias for different location versus same location, $t(15) = -5.93$, $p < .001$, $d = -1.48$, where response

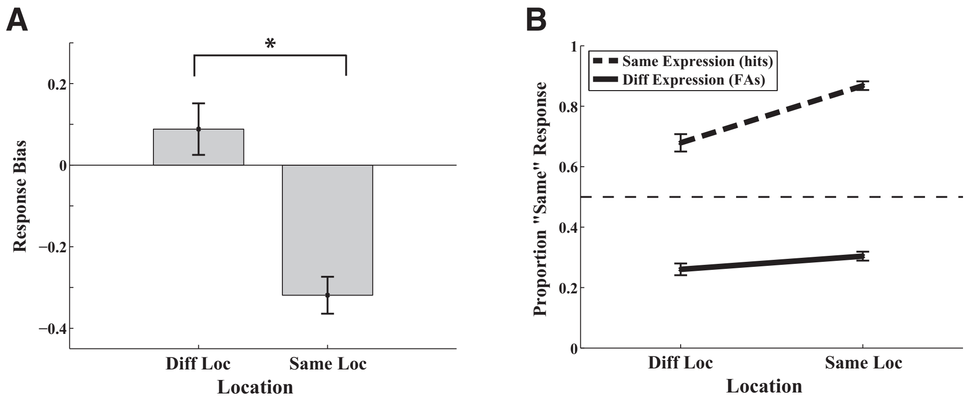

Figure 2. Experiment 1 results: Facial expression task, same identity. a: Response bias (criterion) for the expression task plotted for same and different location conditions. A negative response bias indicates that participants are more likely to judge two facial expressions as the same; a positive response bias indicates that participants are more likely to judge two facial expressions as different. A comparison of these two conditions (black bracket) reveals a significant spatial congruency bias. b: To illustrate the effect in another way, the proportion of "same expression" responses is shown broken down by expression and location. Dashed line show hits (same expression presented); solid line shows false alarms (different expression presented). Chance is 0.5 (50%). Error bars represent standard error of the mean; star indicates $p < .05$ (paired t tests). $N = 16$. Diff = different; Loc = location.

bias was significantly more negative (indicating a greater tendency to respond "same expression") when the two faces appeared in the same location, compared to different locations (Figure 2a). Thus, in Experiment 1, when the two face stimuli were the same identity, we found a significant spatial congruency bias for the facial expression judgment.

Sensitivity and RT. As in prior studies, stimulus location also influenced sensitivity and RT. In regards to sensitivity, d' was significantly influenced by stimulus location, $t(15) = 4.70$, $p < .001$, $d = 1.17$. RT was significantly faster, $t(15) = 4.19$, $p = .001$, $d = 1.04$ in same location compared to different location trials.

Discussion

In Experiment 1 we found a significant spatial congruency bias when participants made judgments of facial expressions. Participants were more biased toward reporting the facial expressions of the stimuli to be the same if the images were presented in the same location. This suggests that the spatial congruency bias can extend to quite high-level visual comparisons. However, in Experiment 1, the two stimuli being compared on each trial always shared the same facial identity, and in fact were identical images when the expressions were the same. Thus, it is possible that participants could have been comparing low-level visual features of the images instead, in making the same/different judgments. In other words, they could have been relying on a low-level visual image-matching strategy rather than a higher-level facial expression judgment. To tease these possibilities apart, in Experiment 2 we eliminated the image-matching possibility by having participants make judgments of facial expressions of emotion across different facial identities. In Experiment 3 we do the analogous manipulation for the facial identity task, by having participants make judgments of same/different identity across stimuli exhibiting different facial expressions.

Table 1
Experiment 1: Facial Expression Task, Same Identity

Measure	Same/diff expression	Same loc	Diff loc
RT (s)	Same expression	0.918 (.13)	0.980 (.16)
	Diff expression	0.937 (.19)	0.952 (.16)
Accuracy	Same expression	0.87 (.06)	0.68 (.11)
	Diff expression	0.70 (.06)	0.74 (.08)
P ("same" response)	Same expression	0.87 (.06)	0.68 (.11)
	Diff expression	0.30 (.06)	0.26 (.08)
d-prime		1.68 (.30)	1.15 (.34)
Response bias (criterion)		−0.32 (.18)	0.09 (.25)

Note. Values listed are means, with standard deviation in parentheses. RT = reaction time; Diff = different; Loc = location; P = proportion "same" response.

Experiment 2: Facial Expression Task, Across Identity

Overview

In the first experiment, a spatial congruency bias was found when participants were asked to judge facial expression of targets sharing the same facial identity. In Experiment 2, stimuli were always of *different* facial identities, such that participants would be unable to strictly "image-match" the low-level features of both stimuli. As in Experiment 1, stimuli were presented in four conditions: same or different facial expression (task-relevant dimension) by same or different location (task-irrelevant dimension).

Method

Subjects. Sixteen subjects (10 females, six males; mean age = 19.12 years; range: 18–24) participated in this experiment.

Stimuli. Stimuli were the exact same set of 8 images as outlined in Experiment 1. The only difference is that during the experiment, each trial always presented two faces of different identities, instead of two faces of the same identity (Figure 1d). The first face stimulus was randomly chosen from the eight identities and four expression categories on each trial. The morph level was selected as in Experiment 1. The second face stimulus was chosen from one of the seven other identities. On same expression trials, the second face was chosen from the same expression category and had an equal morph value. On different expression trials, the second face was chosen from a different expression category, but again with the same morph value. For example, if stimulus 1 was Face A chosen from the happy-to-neutral category and had a morph value of 10 (80% happy), stimulus 2 could have been Face B from the surprised-to-neutral category with a morph value of 10 (80% surprised). Same and different location conditions were identical to those outlined in Experiment 1, and all other details of the task were also identical.

Results

Our primary effect of interest is the spatial congruency bias, calculated as the difference in response bias for same versus different location conditions. Figure 3 shows the response bias, along with the proportion of “same expression” responses illustrating hit and false alarm rates, for same and different location conditions. Table 2 reports means (and standard deviations) for RT, d-prime, proportion “same” responses, response bias, and accuracy.

Spatial congruency bias. Unlike the results of the previous experiment, we found no evidence for a spatial congruency bias when participants were judging whether two faces were the same/different expression, when the facial identity was always different. Paired t tests confirmed there was no significant difference between response bias for same versus different location conditions, $t(15) = .053$, $p = .958$, $d = 0.01$.

Table 2
Experiment 2: Facial Expression Task, Across Identity

Measure	Same/diff expression	Same loc	Diff loc
RT (s)	Same expression	.994 (.25)	.991 (.25)
	Diff expression	.987 (.24)	.986 (.26)
Accuracy	Same expression	0.71 (.08)	0.71 (.07)
	Diff expression	0.64 (.11)	0.64 (.10)
P (“same” response)	Same expression	0.71 (.08)	0.71 (.07)
	Diff expression	0.36 (.11)	0.36 (.10)
d-prime		0.94 (.32)	0.94 (.28)
Response bias (criterion)		−0.10 (.23)	−0.10 (.19)

Note. Values listed are means, with standard deviation in parentheses. RT = reaction time; Loc = location; Diff = different; P = proportion “same” response.

Sensitivity and RT. Stimulus location also did not influence sensitivity (d') or RT in this experiment. Neither measure was significantly different for same location compared to different location trials, $t(15) = -0.03$, $p = .975$, $d = -0.007$ and $t(15) = -.201$, $p = .844$, $d = -.05$, respectively.

Discussion

In Experiment 2, we did not find a spatial congruency bias when participants made judgments of facial expressions. Participants displayed a small overall response bias to report the faces as having the same facial expressions, but this response bias did not vary as a function of where stimuli were presented. These results are in contrast to Experiment 1, indicating that for expression judgments, the spatial congruency bias is only present when the two stimuli being compared are the same facial identity, or when

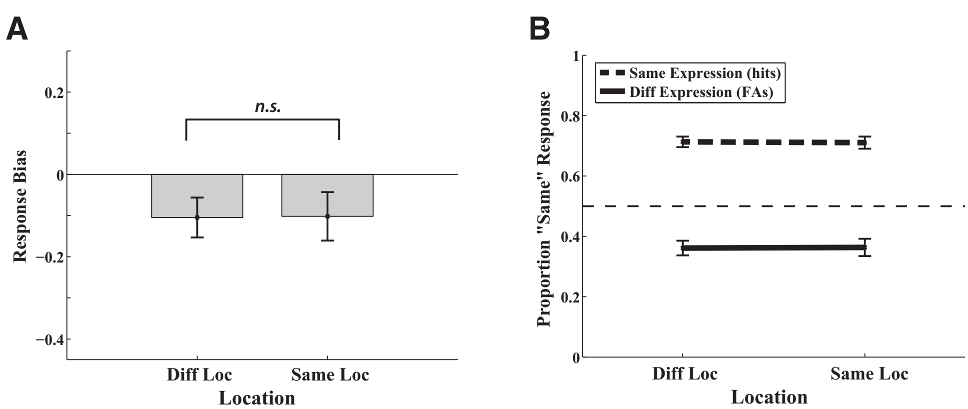

Figure 3. Experiment 2: Facial expression task, across identity. a: Response bias (criterion) for the expression task plotted for same and different location. A negative response bias indicates that participants are more likely to judge two facial expressions as the same; a positive response bias indicates that participants are more likely to judge two facial expressions as different. A comparison of these two conditions (black bracket) reveals a lack of significant spatial congruency bias. b: To illustrate the effect in another way, the proportion of “same expression” responses is shown broken down by expression and location. Dashed line show hits (actual same expression); solid line shows false alarms (actual different expression). Chance is 0.5 (50%). Error bars represent standard error of the mean; n.s = nonsignificant, $p < .05$ (paired t tests). $N = 16$. Diff = different; Loc = location.

participants can rely on image-matching of lower-level visual features. Moreover, there also appeared to be a lack of location influence on other behavioral measurements such as sensitivity and RT. Though our response task was not optimized to find RT effects, we had expected to at least find RT priming for same location versus different location trials, given the results of prior spatial congruency bias studies (Golomb et al., 2014). The task in Experiment 2 was more difficult than Experiment 1 and performance was worse overall, but participants were still performing well above chance on the facial expression comparison task.

Experiment 3: Identity Task, Across Facial Expression

Overview

In Experiments 1 and 2 we observed a spatial congruency bias for judgments of facial expressions, but only when the faces being compared were the same identities. What might this mean for the previously reported spatial congruency bias for judgments of facial identity (Shafer-Skelton et al., 2017)? In that prior study, the stimuli never varied in facial expression or any other dimension, so it is possible that a reliance on lower-level visual information present in the stimuli (image-matching) could have played a role in that finding as well. In Experiment 3 we test this by asking whether the spatial congruency bias for facial identity judgments is tolerant of changes in facial expression. On a given trial the two stimuli to be compared were always expressing different expressions. Facial expression was irrelevant to the facial identity task. Stimuli were presented in four conditions: same or different identity (task-relevant dimension) by same or different location (task-irrelevant dimension). If the spatial congruency bias persists here, that could suggest an important difference between the facial identity and facial expression tasks.

Method

Subjects. Sixteen subjects (11 males, five females; *M* age = 26.75 years; range = 18–47) participated in this experiment. Two additional subjects completed the experiment but were excluded for poor task performance (overall accuracy <55%; predetermined threshold).

Stimuli. Stimuli were modified versions of face stimuli chosen from the same set as Experiments 1 and 2. We took several steps to ensure participants were making judgments based on facial identity and not on other physical features. First, we only used female faces with similar skin tones; we selected three of the models from Experiments 1 and 2, along with two new identities. Next, photos were converted to grayscale and were cropped via an oval aperture so that only the individual's face was displayed (Figure 1e). The model's hair was cropped out as studies have shown that hair is an effective tool in identifying an individual (Wright & Sladden, 2003), or at the very least, can disrupt face recognition (Toseeb, Keeble, & Bryant, 2012). This resulted in a total of five female facial identities, each displaying five expression categories (happy, happily surprised, happily disgusted, disgusted, and neutral). We did not use any morphing in this experiment: the unmorphed (100% emotion) faces were used for the task-irrelevant facial expression dimension, and due to the stimulus changes noted above (cropping, grayscale, etc.), the task-relevant facial identity discrimination was sufficiently difficult without requiring morphing on that dimension as well.

The first face stimulus was randomly chosen on each trial from among the possible identities and expressions. The second face stimulus was always chosen from a different expression category. On same identity trials, the second face stimulus was a photo of the same person exhibiting a different expression. On different identity trials, the second face stimulus was a different person and a different expression. Same and different location trials were identical to those outlined in Experiments 1 and 2. Participants were instructed to compare the identities of the people in the photos, regardless of facial expression or spatial location.

Results

Our primary effect of interest is the spatial congruency bias, calculated as the difference in response bias for same versus different location conditions. Figure 4 shows the response bias, along with the proportion of "same identity" responses illustrating hit and false alarm rates, for same and different location conditions. Table 3 reports means (and standard deviations) for RT, d-prime, proportion "same" responses, response bias, and accuracy.

Spatial congruency bias. In Experiment 3, we found a significant spatial congruency bias when participants judged whether the two faces were the same identity, even though the comparison was across different facial expressions. Paired *t* tests revealed a significant difference concerning the effect of location on response bias, $t(15) = -2.36$, $p = .032$, $d = -.591$. Response bias was significantly more negative (indicating a greater tendency to respond "same identity") for stimuli appearing in the same location, in contrast to different locations (Figure 4a).

Sensitivity and RT. In Experiment 3, stimulus location also influenced both sensitivity (d'), $t(15) = 3.11$, $p = .007$, $d = .778$, and RT, $t(15) = 3.28$, $p = .005$, $d = .819$. Performance was better and faster in same location compared to different location trials.

Discussion

In Experiment 3 we found a significant spatial congruency bias when participants made judgments on the identity of faces, even when the faces displayed different facial expressions. Participants were more likely to report two facial identities as being the same if the stimuli were presented in the same location. Note that the absence of staircasing in this experiment would only be expected to add noise, working against the effect we found. This finding is in accordance with the results of Shafer-Skelton et al. (2017), that found a spatial congruency bias for facial identity on judgments of computer-generated morph faces. Critically, though stimuli in Shafer-Skelton et al. (2017) all displayed the same neutral expression, stimulus pairs in Experiment 3 always displayed different facial expressions. Thus, these results provide a strong contrast to Experiment 2, demonstrating that the spatial congruency bias persists for some higher-level visual comparisons even when a low-level image-matching strategy is not available and suggesting a difference between identity and expression judgments.

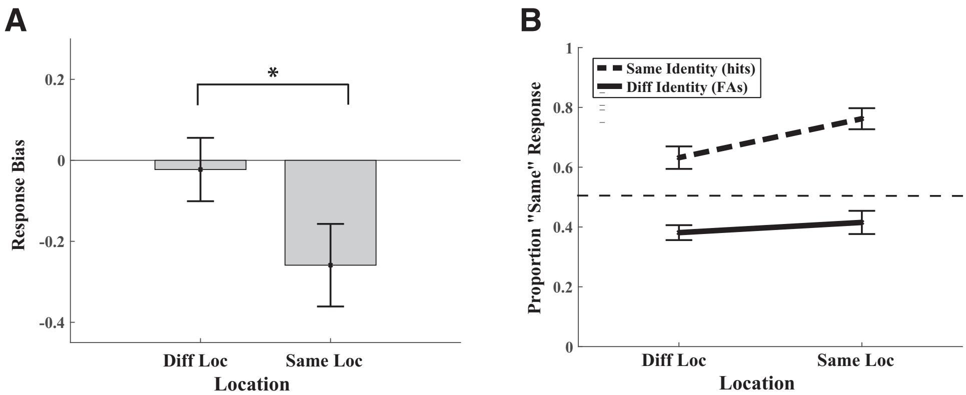

Figure 4. Experiment 3: Identity task, across facial expression. a: Response bias (criterion) for the identity task plotted for same and different location. A negative response bias indicates that participants are more likely to judge two facial identities as the same; a positive response bias indicates that participants are more likely to judge two facial identities as different. A comparison of these two conditions (black bracket) reveals a significant spatial congruency bias. b: To illustrate the effect in another way, the proportion of "same identity" responses is shown broken down by identity and location. Dashed line show hits (actual same identity); solid line shows false alarms (actual different identity). Chance is 0.5 (50%). Error bars represent standard error of the mean; star indicates $p < .05$ (paired *t* tests). $N = 16$. Diff = different; Loc = location.

Between-Experiments Analyses

To summarize the results reported above for each experiment, we found a significant spatial congruency bias in Experiments 1 and 3 but not in Experiment 2. To test whether there were significant differences across experiments, we conducted a series of 2 × 2 between-experiment ANOVAs on the response bias measure, with location (same, different) as a within-participants factor and experiment as a between-participants factor.

For Experiments 1 and 2, a significant main effect was found for location, $F(1, 30) = 21.57$, $p < .001$, $\eta^2 = .418$, indicative of an overall spatial congruency bias. The main effect of experiment was not significant, $F(1, 30) = .036$, $p = .851$, $\eta^2 = .001$, suggesting that there was no difference in overall (average) response bias across experiments. Critically, a significant interaction was found between location and experiment, $F(1, 30) = 22.18$, $p < .001$, $\eta^2 = .425$, revealing that the difference in spatial congruency bias between Experiments 1 and 2 was indeed significant.

Comparing Experiments 2 and 3, we similarly found a significant main effect for location, $F(1, 30) = 4.23$, $p = .048$, η2 = .124, and no significant main effect for experiment, $F(1, 30) = .177$, $p = .677$, $\eta^2 = .006$. A significant interaction was found between location and experiment, $F(1, 30) = 4.44$, $p = .043$, $\eta^2 = .129$, revealing a significant difference in spatial congruency bias between Experiments 2 and 3.

Lastly, for Experiments 1 and 3, there was again a significant main effect for location, $F(1, 30) = 28.18$, $p < .001$, η2 = .484, and no significant main effect for experiment, $F(1, 30) = .086$, $p = .772$, $\eta^2 = .003$. However, in this comparison, the interaction between location and experiment was not significant, $F(1, 30) = 1.99$, $p = .168$, $\eta^2 = .062$, consistent with the finding of a robust spatial congruency bias in both Experiments 1 and 3.

Table 3
Experiment 3: Identity Task, Across Facial Expression

Measure	Same/diff identity	Same loc	Diff loc
RT (s)	Same identity	0.910 (.24)	0.946 (.26)
	Diff identity	0.929 (.24)	0.954 (.24)
Accuracy	Same identity	0.76 (.14)	0.63 (.15)
	Diff identity	0.58 (.16)	0.62 (.10)
P ("same" response)	Same identity	0.76 (.14)	0.63 (.15)
	Diff identity	0.42 (.16)	0.38 (.10)
d-prime		1.01 (.35)	0.68 (.32)
Response bias (criterion)		−0.26 (.41)	−0.02 (.31)

Note. Values listed are means, with standard deviation in parentheses. RT = reaction time; Loc = location; Diff = different; P = proportion "same" response.

General Discussion

In the current study, we asked if judgments of facial identity and expression differ in terms of the low-level, automatic binding of location information captured by the spatial congruency bias. Here, we instructed participants to make same/different judgments on the facial expression or identity of two sequentially presented faces. Across three experiments, we found a robust spatial congruency bias for facial identity and a more fragile one for facial expression. Although the spatial congruency bias for facial expressions was present only when the facial identity dimension was held the same, the spatial congruency bias for facial identity was present even when facial expressions differed.

The Spatial Congruency Bias and Location-Object Binding

The spatial congruency bias (Golomb et al., 2014) is an increased tendency for participants to judge two sequential objects as being the "same" (or more similar), when they appear in the same spatial location. It is thought to reflect the influence location has on object representations, providing support that location is automatically encoded and bound during object processing. Consequently, manipulation of object location may cause variations in perceived object similarity. This makes sense from an ecological perspective, since objects in our environment that occupy the same location in space are generally more likely to *be* the same object, that is, outside the experimental context, an object remaining in the same location is likely to maintain the same identity.

Previous studies have found that a pair of objects appearing in the same visual location is more likely to be judged as the same orientation, letter string, or shape, compared to a pair of objects appearing in different visual locations (Cave & Chen, 2017; Golomb et al., 2014; Shafer-Skelton et al., 2017). In addition to these lower-level object judgments, Shafer-Skelton et al. (2017) also found that participants were more likely to judge two faces as being of the same identity if they were presented in the same location. In the current paper, we extended these findings from computer-generated faces to more naturalistic photographs of real faces and asked how the spatial congruency bias—and its implications for location-object binding—differs for judgments of facial identity versus facial expression.

Judgments of Facial Expression

In Experiment 1, we found a spatial congruency bias when observers were asked to judge the facial expressions of the stimuli. Participants were more likely to judge two facial expressions as being the same if they were presented in the same location. Although the finding of a spatial congruency bias for facial expressions is notable, it is important to note that stimuli in this experiment were always of the same facial identity on any given trial. That is, when the two stimuli were of the same facial expression, they were completely identical images, which could have enabled participants to use lower-level visual properties of the images in making the same/different judgments; for example, participants could have employed a literal visual image-matching strategy instead of a more abstract facial expression judgment. This would not take away from the finding that the spatial congruency bias can affect judgments of facial expressions, but the interpretation and implications could differ.

The results of Experiment 2 reveal that the above spatial congruency bias for facial expression was not tolerant to changes in facial identity. There are several possible explanations for this pattern. First, as noted above, participants may have employed a lower-level image-matching strategy in Experiment 1, and the spatial congruency bias may operate more at this level of processing. Because Experiment 1 was within-identity, it may also have been more efficient for participants to focus on particular facial features (e.g., raised eyebrows on a surprised face) rather than processing the entire face. If participants were more focused on low-level visual features or face parts, they may have been relying more on early visual processing regions in Experiment 1, which are perhaps more susceptible to the influence of spatial location.

An alternative explanation is that the spatial congruency bias found in Experiment 1 did reflect an effect on higher-level representations of facial expressions, and the lack of an effect in Experiment 2 reflects a theoretically interesting difference in the conditions under which the spatial congruency bias is present. For example, perhaps the spatial congruency bias only applies in contexts when the two stimuli being compared could be plausibly seen as the same object. If this were the case, when two obviously different facial identities are presented, the object-location binding is broken, and location no longer influences the judgment. This account could explain why there was a robust spatial congruency bias for within-identity facial expression comparisons but no bias for across-identity facial expression comparisons. (It could also explain why the spatial congruency bias persisted in Experiment 3, since differences in facial expressions may be treated as more malleable object properties; see below.) Moreover, this account could provide a parsimonious explanation for a previous finding from the original spatial congruency bias paper (Golomb et al., 2014), where an experiment manipulated color, shape, and location (their Experiment 6) and found that on a color task, a spatial congruency bias was found for trials on which shape was the same, but not trials on which shape was different.

The pattern of data we found across Experiments 1 and 2—where we observed a spatial congruency bias for the facial expression task on within-identity faces but not across-identity faces—also reveals an intriguing parallel with another phenomenon, the serial dependence effect. The serial dependence effect first noted by Fischer and Whitney (2014) describes how an observer's perception of the features of a current stimulus can be biased by the features of previously viewed stimuli. The nature of the perceptual task is different—that is, reporting the orientation of the current stimulus for the serial dependence effect rather than directly comparing two stimuli in the spatial congruency bias—and the serial dependence effect is primarily thought of as an influence of temporal proximity, but it is likely the two phenomena may be related. Interestingly, both phenomena were discovered around the same time (Fischer & Whitney, 2014; Golomb et al., 2014), and both have subsequently—and independently—revealed a similar pattern when extended to face judgments. The serial dependence effect has been demonstrated in complex examples such as facial identity perception (Liberman et al., 2014), facial attractiveness (Xia, Leib, & Whitney, 2016), and facial expressions (Liberman et al., 2018), but tellingly, the serial dependence effect for facial expression has been shown to be less salient when targets have dissimilar identities (Liberman et al., 2018). Interestingly, serial dependence for facial expression was also shown to be selective to the gender of the target but not the ethnicity, allowing authors to conclude that this effect may be modulated by face similarity (Liberman et al., 2018). The potential link between the serial dependence effect and the spatial congruency bias is intriguing and requires more study, and the two sets of findings complement each other well. That said, the critical difference is that we specifically find this increased tendency to report faces as the same identity (and to a lesser extent the same expression) when they appear in the same *location*; thus, the primary contribution here is the automatic (or not) binding of spatial location information to an object's higher-level features.

Facial Expression Versus Facial Identity Judgments

The results of Experiments 1 and 2 revealed a fragile spatial congruency bias for facial expression judgments. In contrast, the results of Experiment 3 suggest the spatial congruency bias is more robust for facial identity judgments. Here, a spatial congruency bias for facial identity was still observable even across stimuli exhibiting different facial expressions of emotion. Specifically, participants were more likely to judge two images as being of the same person if they were presented in the same spatial location, regardless of their facial expression.

The difference in the results between Experiments 2 and 3 may be explained by the relative time-courses of facial expression and identity processing. The relationship between facial expression and facial identity processing is widely debated among cognitive scientists. Some researchers have posed that facial identity and facial expression processing operate independent to each other (Bruce & Young, 1986; Hasselmo, Rolls, & Baylis, 1989), whereas others suggest that these processes mutually interact with each other (Ganel, Goshen-Gottstein, & Ganel, 2004; Yankouskaya, Booth, & Humphreys, 2012). Furthermore, it has been proposed that this interaction between facial identity and facial expression processing is supported by an asymmetric dependent relationship between them (Schweinberger, Burton, & Kelly, 1999; Schweinberger & Soukup, 1998), and that the degree of independence may depend on the nature of the stimulus or behavioral task (Haxby, Hoffman, & Gobbini, 2002; Yankouskaya et al., 2014).

The asymmetric dependence studies have generally suggested that a face's identity can be processed without facial expression information, but facial expression cannot be processed independently of the facial identity (Schweinberger & Soukup, 1998). In tasks where both facial identity and expression are variables, studies have noted that participants are faster in facial expression search tasks when all the facial identities of the stimuli are congruent (Carvajal, Vidriales, Rubio, & Martín, 2004; Zhang, Xuan, & Fu, 2005). People have also been shown to be more efficient in recognizing facial expressions on familiar faces and for repeated faces that were shown earlier in an experiment, compared to novel faces (Baudouin, Sansone, & Tiberghien, 2000), again suggesting an influence of facial identity on facial expression processing. However, other recent studies have concluded the opposite pattern of dependence; for example, using a multidimensional modeling approach based on general recognition theory, Soto, Vucovich, Musgrave, and Ashby (2015) concluded that perception of facial expression may not be affected by changes in facial identity, whereas facial identity perception may be affected by changes in facial expression.

The asymmetry we found between the results of Experiments 2 and 3 could be consistent with an asymmetric relationship between facial identity and expression processing, particularly the explanations given by Schweinberger et al. (1999) and Schweinberger and Soukup (1998) that supported a dependency of facial expression on facial identity but not vice versa. If participants were not able to separate facial identity information when making judgments on facial expression in Experiment 2, this might have eliminated or obscured the spatial congruency bias in the different-identity condition. In contrast, if facial identity judgments are less dependent on expression information and facial expression information does not influence identity judgments, that could explain why a spatial congruency bias was observed for identity regardless of whether the faces exhibited the same or different expression in Experiment 3.

It is also possible that an asymmetric relationship between facial identity and expression processing could predict differences in location-object binding directly. For example, it is possible that location information is bound to facial identity information (a stable object property), but not to facial expression information (a more changeable, perhaps secondary object property); if true, then the spatial congruency bias might only be found for identity judgments, or for facial expression judgments within the same identity. As noted above, the spatial congruency bias is believed to reflect an automatic binding of object location information to object identity and features, and it is possible that static features and dynamic features are bound differently during object integration. Such an account could be consistent with the ecological relevance argument noted earlier: One theoretical explanation that has been proposed for the spatial congruency bias is that it may reflect learned assumptions about the world—that congruent spatial location can be a cue for object stability (Golomb et al., 2014). When humans perceive faces in their environment, it is less likely for a face to abruptly change its identity, whereas the facial expression on a face is dynamic and thus more likely to change in an instant. Thus, if a participant glimpses two faces in rapid succession in the same spatial location, they may be biased to perceive them as the same identity, but the same learned assumption may not hold for dynamic object properties like facial expression.

Another possible reason we might see a difference in the spatial congruency bias between the two tasks could be related to a difference in how various brain regions represent location information. The degree to which facial identity and expression processing overlap in the brain is debated (Bruce & Young, 1986; Carvajal et al., 2004; Ganel, Valyear, Goshen-Gottstein, & Goodale, 2005; Young, McWeeny, Hay, & Ellis, 1986), but a common theory is that they are processed in independent but connected neural systems (Hasselmo et al., 1989; Haxby et al., 2000, 2002). Neuroimaging studies have suggested these two processes recruit different regions of the brain during processing (Haxby et al., 2002). Specifically, the posterior superior temporal sulcus has been shown to be preferentially activated when observers view changeable aspects of faces, such as dynamic movement of facial parts (Puce, Allison, Bentin, Gore, & McCarthy, 1998), or facial action unit perception (Srinivasan et al., 2016); whereas static or invariant facial features have been shown to elicit more activation in regions like the fusiform face area (Haxby et al., 2000; Kanwisher & Barton, 2011). Interestingly, a recent paper found that these two regions show different selectivity across the visual field (Pitcher et al., 2019). The FFA has been shown to preferentially respond to stimuli presented in certain areas of the visual field (Pitcher et al., 2019; Silson, Chan, Reynolds, Kravitz, & Baker, 2015), whereas the pSTS does not appear to exhibit any visual field preference, including a lack of contralateral field bias (Pitcher et al., 2019). If regions dedicated to facial identity processing are more sensitive to location information than regions dedicated to facial expression processing, this may also help explain why we see a robust spatial congruency bias in Experiment 3 for the identity judgments but not in Experiment 2 for the expression judgments.

Image-Matching and Other Strategies

The different pattern of results for Experiment 1 (facial expression task, same identity) and Experiment 2 (facial expression task, across identity) raised an important concern about the type of judgments participants might actually be making in this same/different task. Although it is possible that the results reflect a theoretically interesting dependence of expression judgments on facial identity similarity, it is also possible that participants were simply matching lower-level visual properties of the images (e.g., pixel-by-pixel similarity) in Experiment 1, and that the spatial congruency bias might not extend to higher-level visual processing at all. In other words, perhaps the reason a prior paper (Shafer-Skelton et al., 2017) found no effect of stimulus complexity on the spatial congruency bias was because in all cases participants could still rely on low-level visual features to do the task.

Importantly, the results of Experiment 3 seem to dispel this notion that the availability of an image-matching strategy is necessary in order to observe a spatial congruency bias. Here, we observed a spatial congruency bias for facial identity judgments even across stimuli exhibiting different facial expressions of emotion. However, it is possible that participants may still have been able to use some low-level information in making these judgments, and that the amount of low-level information might have been different in the two cases (facial expression across different identities, vs. identity across different facial expressions). Because the stimuli we used for Experiments 2 and 3 contained some key differences (color vs. grayscale, presence vs. cropping of hair and other background features), it is difficult to directly compare the low-level information across experiments. However, an exploratory pixel-wise correlation analysis across pairs of images suggests that while low-level image matching could not be used deterministically in either Experiment 2 or 3, there may have been more probabilistic low-level similarity information present in the stimulus set for Experiment 3 than in Experiment 2 (i.e., the "same identity" image pairs in Experiment 3 may have still been overall more visually similar than "different identity" image pairs, even though the exact images were never the same in either case). Importantly, however, the spatial congruency bias in Experiment 3 was just as strong as the previously reported spatial congruency bias for facial identity judgments within the same expression, where identical images were repeated on "same" trials (Shafer-Skelton et al., 2017). Thus, our pattern of results does not seem consistent with low-level features being the sole driver of the spatial congruency bias. In other words, although we cannot rule out that participants are using some low-level information to make facial identity judgments in Experiment 3, it is unlikely that this could completely account for our results. Instead, we suggest that the difference may have more to do with the nature of identity versus expression judgments, as speculated above.

A related question is whether the physical differences in stimuli across tasks (e.g., availability of color image information, hair/background cropping, and gender variation) might have contributed to a different processing strategy and/or attentional focus across tasks. A recent paper by Cave and Chen (2017) identified an additional type of bias related to analytic versus holistic processing strategies during visual comparison tasks. They found that when stimuli could be compared as unified wholes, participants tended to use a holistic strategy, resulting in an overall greater bias to report the items as the "same," whereas participants tended to use an analytic comparison strategy when parts of the stimuli must be compared individually, resulting in an overall bias to say "different." Critically, this analytic/holistic bias appears to be orthogonal to the spatial congruency bias; in Cave and Chen's study, a spatial congruency bias (difference in bias) was reported for all experiments, regardless of the direction of the overall analytic/holistic bias (Cave & Chen, 2017). In contrast, in the current study we found a complete lack of spatial congruency bias in Experiment 2. Moreover, the between-experiments ANOVA found no significant difference in overall response bias across any of the experiment pairings; in all three experiments there was a slight overall response bias to report "same." Thus, although it is possible that different processing strategies were employed across our three experiments, it seems unlikely that could account for the difference in spatial congruency bias patterns.

Limitations and Open Questions

One limitation of the current study is that face stimuli were always presented in the periphery. This was done because testing the spatial congruency bias requires presenting stimuli in different retinotopic locations (equated for retinal eccentricity). However, many studies have expressed a preference for faces to be processed in central vision (Hasson, Levy, Behrmann, Hendler, & Malach, 2002; Levy et al., 2001), and it has been demonstrated that peripheral vision may be less reliable than in central vision in identifying faces (Mäkelä, Näsänen, Rovamo, & Melmoth, 2001). This foveal preference may be less important for perceiving facial expressions; previous research has concluded that peripheral vision is competent in processing some facial features (Bayle, Schoendorff, Hénaff, & Krolak-Salmon, 2011), and basic facial expressions of emotion can be recognized reliably in the periphery (Calvo, Fernández-Martín, & Nummenmaa, 2014; Smith & Rossit, 2018). We designed our stimuli to be difficult but discriminable in each experiment. Average accuracy on the facial expressions task was 74% in Experiment 1 and 67% in Experiment 2, and average accuracy on the facial identities task was 64% in Experiment 3. Although accuracy was significantly higher in Experiment 1 compared to Experiments 2, $t(25) = 4.93$, $p < .01$, $d = 1.74$, and 3, $t(25) = 6.76$, $p < .01$, $d = 2.39$, there was no significant difference in accuracy between Experiment 2 (expression task across different identities) and Experiment 3 (identity task across different expressions), $t(30) = 1.50$, $p = .141$, $d = .533$, suggesting that difficulty in discriminating between stimuli in the periphery seems unlikely to underlie our basic result. However, an interesting question for future research could be how object-location binding and spatial location influences on facial identity and expression processing might differ for stimuli presented in the periphery or for which observers are allowed to fixate on directly.

Another open question is whether the spatial congruency bias might vary for different expressions, given that we selected only a subset of recognizable facial expressions of emotion (Du et al., 2014) and did not test facial expressions displaying negative valence. Our study was also not designed to look at differences related to gender or race, which could also be interesting questions for future study.

The results of the current study may encourage further insight on the effects of spatial location on facial expression and facial identity processing. Further investigation into this understudied topic may reveal potential expectations humans have for faces when they are processed in our natural environment.

Conclusion

In conclusion, we report a robust spatial congruency bias for facial identity judgments and a more fragile effect for facial expression judgments. The spatial congruency bias is a difference in response bias for stimuli presented in the same compared to different locations, thought to capture an automatic influence of low-level spatial location during object recognition (Bapat et al., 2017; Finlayson & Golomb, 2016; Golomb et al., 2014; Shafer-Skelton et al., 2017), where stimuli appearing in the same spatial location are more likely to be perceived as the same object. The current study demonstrates the presence of a spatial congruency bias for higher-level judgments of facial expression and identity for real-world faces. Here we showed that participants are more likely to judge two sequential faces as being the same facial identity if they are presented in the same location compared to in different locations, even when they differ in facial expression. Interestingly, when participants make judgments on facial expression, this effect occurs only when the faces being compared share the same identity; the spatial congruency bias for expression judgments is eliminated when the faces differ in facial identity. These results may provide support of an asymmetrical relationship between facial expression and facial identity processing and a potential difference in the pervasiveness of object-location binding for higher-order object properties.

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